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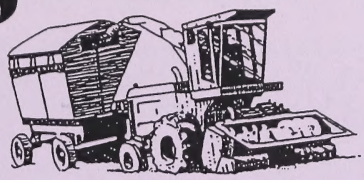

FALL FERTILIZATION - WHAT ARE THE ADVANTAGES AND DISADVANTAGES?

Ross H. McKenzie Doug Penney Elston Solberg

Farmers frequently ask about the advantages of fall versus spring fertilization with nitrogen (N). Depending on soil moisture conditions, environmental conditions, type of N fertilizer used and the method of application, the effectiveness of fall fertilization can range from excellent to disastrous. In other words, a number of factors must be considered, to determine whether or not fertilizing this fall is best for you.

Let's start with a quick review of the fate of N fertilizer in soil. Fertilizer N can be applied to soil in the form of urea [$CO(NH_2)_2$], anhydrous ammonia (NH_3), ammonium (NH_4^+) or nitrate (NO_4^-) depending on the type of product used. Urea and anhydrous ammonia quickly convert to ammonium. It is the ammonium and nitrate forms that are taken up by plants. If the soil is warm, moist and well aerated, ammonium is rapidly oxidized to nitrate through the nitrification process. This is a biological process performed by highly specialized bacteria.

Banding N fertilizer slows the nitrification process by creating an environment near the band that inhibits the activity of the bacteria converting ammonium to nitrate. Therefore, if urea or anhydrous ammonia is banded in late fall, most of the N is retained in the ammonium form until the soil warms up in the spring. If the fertilizer is broadcast or banded in early fall, most of the ammonium will be converted to nitrate prior to freeze–up. Twenty years of research in Alberta has shown that if fall applied N is converted to nitrate prior to freeze–up, large losses can occur when soils are water saturated during and just after snow melt in early spring. The losses are caused by an anaerobic process called denitrification which converts nitrate to nitrogen gas.

In terms of fertilizer management this means no soil type or region of Alberta is 100% safe when it comes to losses of fall applied N. However, the level of risk of overwinter N loss is greatest in regions with moister climates such as west central Alberta. There is less risk in regions that tend to be drier such as southern Alberta, but even in these regions N losses can be higher during a wet spring. In general, though, N losses through denitrification in the drier regions are relatively small and therefore, fall banded N is equal to spring banded N in these areas. In fact, where spring banding causes a significant loss of seedbed moisture, fall banding is superior to spring banding.

From this we can develop some general rules about NITROGEN application methods and timing:

- Generally spring banding is the most effective method of application and fall broadcast the least effective.
- Fall banded N will be as effective as spring banded N if there is no extended period of saturation in the spring.
- Fall banded N may be more effective than spring banded N when lack of seedbed moisture is a concern.

Continued Page 2

This Issue:

- **Fall Fertilization – What Are The Advantages And Disadvantages?**
- **Tillage And Crop Disease Control**
- **Fall Herbicide Application Makes Sense**
- **Diagnostic Field School**
- **Diagnosing Copper Deficiency**
- **Cleaning Up That Weed Sprayer**
- **Soil Sampling – The Need For A New Approach**
- ***"Dear AGGIE"***
- **Personal Comments – Friendly Farming**

Alberta
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Fall Fertilization Continued

With this information in mind, here are a few tips to consider before you fertilize this fall:

1. Soil test to determine the optimum rates of fertilizer required. We always encourage producers to sample 0–6, 6–12, and 12–24 inch depths to determine the cumulative N to two feet.

2. Apply a conservative rate, say 75% of soil test recommendation, or 75% of what you would expect to apply, if you haven't received your results at the time of application. The conservative rate is a hedge against such things as high soil test N levels or low spring soil moisture levels. If conditions look favourable next spring, additional N can be drilled in with the seed.

3. Select a fertilizer formulation that is right for your conditions. Generally, under low risk conditions such as southern Alberta, anhydrous ammonia (82–0–0), urea (46–0–0), ammonium nitrate (34–0–0) or liquid N (28–0–0) perform equally well when banded. However, in higher pH soils, losses through ammonia volatilization can occur if the bands are too shallow or the soil is dry and cloddy.

4. Avoid the use of nitrate containing fertilizers (eg. 34–0–0, 28–0–0) on soils that tend to be saturated in the spring. Nitrates are subject to both denitrification and leaching losses under wet spring conditions.

5. Apply N in late fall after the soil temperature has dropped below 7° C. and the nitrification process has slowed down.

6. Band don't broadcast. Banding restricts the contact between soil and fertilizer and as a result overwinter losses are lower.

Other management factors you should consider include:

- Fall fertilization can improve your time management. By applying fertilizer in the fall, an operation can be eliminated next spring.
- Fertilizer prices and payment schedules tend to be more favourable in the fall versus spring.
- Availability of product and equipment is often better in fall than during the peak demand periods in spring.

This covers some of the major points you should keep in mind when making your decision to fertilize this fall. If you have any questions arising from this article or other aspects of soil fertility give us a call.

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Chinese Agronomists Visit Soil & Crop Management Branch

The Soil & Crop Management Branch is currently hosting 14 Chinese agronomists for a 3 month period. They are here as part of the Balance Fertilization Project sponsored by the United Nations Development Program (UNDP). They are being trained in laboratory methods, laboratory management and agronomic research. Expertise at the University of Alberta and Conservation & Development Branch is also being utilized. Training costs are being looked after by the UNDP while we gain valuable experience and contacts for similar future ventures.

TILLAGE AND CROP DISEASE CONTROL

Ieuan R. Evans

What are some of the implications of zero till or minimum till on crop diseases? The answer will depend on the crop grown and its location in Alberta.

Canola Stubble

It is always recommended that canola stubble be worked under if virulent blackleg is present in the field. The blackleg fungus can only survive on intact canola stubble. Canola stubble will breakdown much faster in the soil than on the soil surface. In addition buried stubble cannot release infectious blackleg, blackspot and staghead spores onto the soil surface. In the case of sclerotinia white mold, burying the black sclerotia 3–4 inches deep will prevent the development of the tiny spore producing apothecia from reaching the soil surface. It can then be concluded that burial of canola residue is positive when destructive diseases are present because it speeds up their breakdown and reduces their spread. If the soil on which a canola crop was grown is subject to wind or water erosion then working under canola stubble should definitely be left until the following spring. Of course, if none of the above diseases are present, then there is little need to work under canola stubble.

Cereal Straw

Many foliar diseases are carried on cereal straw. On wheat there is tan spot and septoria, and on barley there will be septoria, scald and net blotch. Oat and rye straw generally carry relatively little in the way of significant foliar disease. The foliar diseases that affect wheat, barley, oats or rye are usually highly specific to that cereal crop. Thus net blotch (or scald) of barley will only affect barley. Oats, rye and wheat are immune to this disease. Although the symptoms of septoria diseases appear similiar in wheat, oats and barley, the septoria strain on barley is specific to barley and will generally not cause any appreciable disease on oats or wheat.

In west central Alberta foliar disease of wheat and barley can reduce yields by up to 25% or more with an

accompanying drop in bushel weight and quality. In the dryer eastern regions of the province, foliar diseases may cause minor yield losses but moisture shortage is the greatest yield limiting factor. Consequently deep cultivation of the stubble, by reducing the disease potential, would likely benefit a Stony Plain barley grower particularly if he was growing barley after barley. A Coronation wheat grower would likely benefit more from moisture conservation under zero minimum till than reduced disease potential resulting from cultivation.

In the spring, minimum or zero till soil tends to warm up slower than cultivated soil with good moisture. The residue present on the soil surface reflects the sunlight, reducing heat absorption. The cooler soil slows seed germination and reduces the seedling vigor. The reduction in vigor increases the severity of seedling diseases such as damping–off and seedling blight. Residue from the previous crops may increase seedling disease and reduce stand establishment. It is essential to use treated seed, with a high germination and vigor test in zero and minimum till situations due to the greater disease and environmental pressures on stand establishment.

Researchers, worldwide, are working to produce black pigmented cereal straw. If successful, this could mean that under minimum or zero till situations, the straw would absorb rather than reflect heat and allow for a faster warm–up of the soil in the spring.

Wheat Streak Mosaic Virus

Minimum or zero till that is not followed–up by timely chemical weed control can lead to destructive outbreaks of wheat streak mosaic virus on both winter wheat and the following spring wheat crops. The key control for this disease in Alberta's southern winter wheat growing areas is the elimination of volunteer spring wheat two weeks prior (early August) to the emergence of the next wheat crop.

Wheat streak mosaic virus spreads via windblown microscopic mites from maturing wheat to volunteer spring or winter wheat in adjacent fields. Spring wheat crops are generally mature by early August and do not support an active infectious mite population, while volunteer winter wheat or spring wheat in adjacent fields will still be green. These volunteer plants can have a highly active mite population and could be 100% infected by the virus. If winter wheat is direct seeded into such a field, very high infection rates can take place and may result in total crop loss. This virus infected, mite infested winter wheat crop will then become a prime source of infection for spring wheat sown on adjacent land (up to a mile away). In addition, volunteer winter wheat in fields sown to spring wheat can become the prime source of infection. All spring and winter wheats are susceptible to wheat streak mosaic virus. Laura spring wheat appears to be particularly susceptible. Barley, oats and rye are immune to this viral disease.

In order to control this highly destructive viral disease, "green volunteer wheat", both spring and winter types, must be cultivated under or killed two weeks prior to the new wheat crop emergence.

For more detailed information on "Wheat Streak Mosaic Virus" control see Agdex 112/632–3 from our Publication Office.

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FALL HERBICIDE APPLICATION MAKES SENSE

Denise Maurice
Dan Cole

Fall spraying is an effective, economical method of controlling weeds. It can be an integral part of a reduced tillage program.

Fall spraying with 2,4–D amine or ester 500 (approximately 500 g/L or 50 per cent formulation) at 0.34–0.45 L/ac will control the winter annual weeds: stinkweed, flixweed, shepherd's–purse and yellow whitlow–grass (Table 1). The herbicide cost will range from $1.50 to $2.00 per acre which is less than the fuel costs to cultivate the land. Narrow–leaved hawk's–beard can usually be controlled in the fall with a slightly higher rate of 0.57 L/ac of 2,4–D ester 500 or 0.50 L/acre of 2,4–D ester 600.

Even though it is a hassle to get the sprayer out again and lines and nozzles can plug up with freezing temperatures, there are a number of advantages to spraying in the fall:

Table 1. Herbicides for fall control of winter annuals

Weed	Herbicide	Rate L/Ac
Stinkweed, Flixweed & Shepherd's–Purse	2,4–D or MCPA Amine 500	0.34–0.45
Bluebur, Common Peppergrass	2,4–D or MCPA Amine 500	0.51–0.60
Narrow–Leaved Hawk's–Beard	2,4–D Ester 500	0.57
Downy Brome	Roundup Rustler	0.40 1.00

NOTE: 2,4–D and MCPA: Ester formulations and other concentrations (active ingredient/litre) may also be used. Consult "Crop Protection with Chemicals", Agdex 606–1, Alberta Agriculture, Food and Rural Development.

- winter annual weeds are more susceptible to herbicides in the fall than in the spring (Table 2).

- lower herbicide rates will control winter annual weeds as compared to spring spraying.
- one or two tillage operations may be saved. Tillage or another spray application may not be needed until June of the following year if the rotation is to summerfallow.
- more crop residue as standing stubble is left to protect the soil from wind and water erosion.
- more moisture is conserved from less tillage, fewer weeds to use the moisture and having standing stubble to trap the snow. A recent study conducted by Dr. Bob Blackshaw and Dr. Wayne Lindwall of Agriculture Canada in Lethbridge has shown this benefit. They found that 17 mm more water was stored on summerfallow if winter annual weeds were controlled with 2,4–D in the fall compared to early May. Treatments were followed by Rustler in June and tillage thereafter. The extra stored water accounted for two bushels per acre more of spring wheat in the next year.
- reduces the risk of injury to the subsequent crop from herbicide residue as compared to spring application of herbicides (Tables 4 and 5).
- reduces the work load during the critical spring seeding period
- reduces the problem of unpredictable weather and soil conditions in the spring and allows for weed control in areas prone to be wet in the spring.

Of course fall spraying depends on favourable weather conditions as well. If conditions permit, 2,4–D can be applied for winter annual weed control from October 1 right up until freeze–up or the first persistent snowfall. Winter annuals do not stop growth with frost as do annuals and most perennial weeds. Spraying too early will miss the weeds that emerge later if there happens to be a long, open fall with later moisture.

Table 2. Effect of application timing on control of winter annual stinkweed and flixweed in winter wheat with 2,4–D Amine.

	Stinkweed		Flixweed	
Application Date*	Plant /m^2	biomass g/m^2	Plants/ m^2	biomass g/m^2
Untreated	11	122	8	40
Sept. 25	1	1	1	7
Oct. 27	0	0	0	0
April 28	1	3	1	6
May 13	6	35	5	43

(K. Kirkland, Agriculture Canada, Scott)
*2,4–D Amine applied at 0.45 L/acre.

It is important to check carefully for the winter annual weeds as they may be very small seedlings in the fall and not very noticeable. However, if newly germinated winter annuals are present, any unsprayed check strip or area will very noticeably show the following spring how effective spraying of 2,4–D on winter annual weeds can be. The distribution of straw and chaff is also a factor as the spray must hit the winter annual weeds in order to have control. Spreading the straw evenly and not spraying until the weeds show through the straw and chaff will aid in their control.

Winter annual weed control can also usually be obtained with spring application (Table 3). However, in most years, application should take place before the end of April. Generally narrow–leaved hawk's beard is harder to kill so it must be sprayed in the fall using at least 0.57 L/ac of 2,4–D ester 500.

Table 3. Herbicides for preseeding (spring burnoff) weed control in conservation tillage

HERBICIDE	WEEDS CONTROLLED
For Wheat, Oats and Barley	
Roundup (0.4 L/ac)	wild oats, green foxtail, stinkweed, wild mustard, lady's–thumb, volunteer cereals & canola
Roundup (0.4 L/ac) + Pardner (0.4 L/ac)	Roundup susceptible annuals, wild buckwheat, lamb's–quarters
Roundup (0.4 L/ac) + 2,4–D Amine 500 (0.5 L/ac)*	Roundup susceptible annuals, redroot pigweed, kochia & flixweed
Roundup (0.4 L/ac) + Banvel (0.12 L/ac)*	Roundup susceptible annuals, Russian thistle, lamb's–quarters, kochia, cow cockle, flixweed & wild buckwheat
Roundup (1.0 L/ac)	Roundup suseptible annuals and season long control of quackgrass
Rustler (1.0 L/ac)*	wild oats, green foxtail, persian darnel, volunteer cereals, wild mustard, kochia, lady's–thumb, lamb's–quarters, stinkweed, Russian thistle, volunteer canola, redroot pigweed, wild buckwheat, downy brome & flixweed
For Oilseed, Legume and Forage Crops	
Roundup (0.4 L/ac)	wild oats, green foxtail, wild mustard, stinkweed, lady's–thumb, volunteer cereals & canola
Roundup (1.0 L/ac)	Roundup susceptible annuals and season long control of quackgrass

*Not registered for preseeding weed control. Soil residue may injure oilseed and legume crop seedlings. Use is entirely at the risk of the user.

Table 4. Effects of soil residues from 2,4–D and dicamba applied 0 and 15 days prior to seeding on several crops

Herbicide	Days before seeding	Yield (check = 100) Canola	Alfalfa	Peas	Lentils
Check		100	100	100	100
Banvel*	15	105	117	91	32
Banvel	0	102	105	85	19
2,4–D Ester**	15	84	87	68	30
2,4–D Ester	0	84	95	50	20
Banvel+*** 2,4–D Ester	15	89	86	75	9
Banvel + 2,4–D Ester	0	85	103	44	10
		(J.R. Moyer, Agriculture Canada, Lethbridge)			

*Banvel @ 0.12 L/ac
**2,4–D Ester @ 0.45 L/ac
***Banvel+2,4–D @ (0.12 + 0.45 L/ac)

Table 5. Effects of residues from fall applications of 2,4–D and dicamba on spring seeded crops

Herbicide	Yield (check = 100) Canola	Alfalfa	Peas	Lentils
Check	100	100	100	100
2,4–D Amine 500 @ 0.34	101	103	110	82
2,4–D Amine 500 @ 0.67	104	98	92	75
2,4–D Ester 500 @ 0.34	100	82	92	86
2,4–D Ester 500 @ 0.67	109	86	94	73
Banvel @ 0.12	96	81	94	74
Banvel @ 0.48	73	42	50	1
Banvel + 2,4–D Amine 500 (0.34 + 0.67)	106	96	97	59
	(J.R. Moyer, Agriculture Canada, Lethbridge)			

Fall spraying provides an excellent opportunity for the control of problem winter annual weeds as well as the possibility of suppressing perennial weeds. It fits in very well with a reduced tillage program and is an effective, economical way of conserving moisture and protecting the soil from erosion. It is well worth trying if it is not already part of your program.

FarmFacts sheet " Chemical Weed Control in Direct Seeding Systems", from Saskatchewan Agriculture and Food has some very relevant information on soil residue concerns with 2,4–D (Tables 4 and 5). For a complete copy of the FarmFacts sheet, please contact us at the Soil and Crop Management Branch.

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1994 DIAGNOSTIC FIELD SCHOOL
Bigger and Better for Year 3!!

Ray Dowbenko SHERRITT | *Elston. Solberg* Soil & Crop Management | *John Harapiak* WESTCO

The 3rd Diagnostic Field School was held over a 6 week period; this past July and August; at the U of A Renewable Resources Soil Science Research Farm near Ellerslie, Alberta. Nineteen (19) groups attended 1 day sessions that were modified each day to target their informational requirements. Over 350 people attended, including many dealer/agronomist groups; from Sherritt, WESTCO, UGG, UFA, Pioneer, Prairie Seeds, North West Agra & the Wheat Pools of Alberta, Saskatchewan & Manitoba; several bunches of farmers and a U of A class.

The Field School provided an interactive setting in which agronomists, researchers and retailers could discuss various aspects of crop management including soil fertility, weed control, variety selection, crop diseases and insect pests.

The original concept was put forward in 1989, but the actual curriculum was not developed until the 1992 and 1993 seasons with technical and financial support from SHERRITT Fertilizers. For 1994, curriculum development expanded as the Diagnostic Field School team grew to include funding and expertise from WESTCO and Field Crops Branch (Murray McLelland & Phil Thomas). The intent of the school is to:

- ☑ Provide agronomic training in critical service and diagnostic areas.
- ☑ Allow for discussion and communication of ideas and concerns related to agriculture across a wide spectrum of extension professionals from industry and government.
- ☑ Act as a feedback mechanism by which crop production concerns and questions can be studied and answered while fostering future development of the Diagnostic Field School.

Some of the topics covered in this years school included seedplaced fertilizer, nitrogen placement methods, seed quality, seeding depth, fungicide treatments, residual herbicide damage, herbicide resistant weeds, variety comparisons, direct seeding strategies, nutrient deficiency symptoms, legume inoculation, fertility-herbicide-seeding depth interactions and many others.

The 3 main topics - fertility, disease and herbicides - were set up to show the interactions between crop limiting factors. This stressed the importance of an integrated approach to solving problems in the field. For example, the importance of quality seed, proper seeding depth and seedbed conditions were discussed in relation to getting the most out of fertility and herbicide programs.

With over 250 demonstrations, it is impossible to review all the topics discussed. It is, however, safe to say that a number of interesting points were made and that the everyone learned new skills that will help them deal with crop protection problems.

The enthusiasm of the students and the synergy developed between industry and Alberta Agriculture research/extension staff once again made the 1994 Diagnostic Field School a resounding success!! Many thanks to all 3rd year participants and an early welcome to those of you planning to attend in 1995.

DIAGNOSING COPPER DEFICIENCY

E. Solberg, D. Penney, D. Maurice & I. Evans

Seven years (1987-93) of copper (Cu) fertility research in central Alberta has allowed us to confidently correct Cu deficiencies once a correct field diagnosis has been made. We now have a good understanding of the management of the many available Cu fertilizers. Recommendations for rates, methods and timing of Cu fertilizer applications are confidently made. Unfortunately, the correct diagnoses of Cu deficiency in the field is often not made with the same confidence and producers are suffering through:

(a) reduced yields when Cu fertilizer is not applied, but required.
(b) unnecessary application of relatively expensive Cu fertilizer.

Our understanding of Cu fertility has changed rather dramatically over the past 7 years. Prior to the mid 1980's, agronomists in Alberta were of the opinion that Cu deficiencies were limited only to deep organic soils (>45 cm.) and Cu deficiency did not affect crops growing on mineral soils. Since 1987, research has identified Cu deficiencies in the Black, transitional Gray-Black and Dark Brown soil zones. The extent of the deficiencies on these soils is not well defined but it is estimated that approximately 3 million acres are potentially Cu deficient. These 3 million acres represent about 10% of Alberta's cultivated acreage; much found within the most productive agroclimatic zones of Alberta. ***Why the big change in thinking??***

Kruger et al. (1985), observed Cu deficiencies on mineral soils in Saskatchewan and suggested that the "critical" level of 0.2 mg/kg DTPA extractable Cu, used at the time, was too low and should be increased to 0.4 mg/kg for Saskatchewan cereals. Penney et al. (1988) observed copper deficiency on central Alberta soils testing 0.6 to 0.8 mg/kg DTPA extractable Cu suggesting that the critical level should be moved up even further. It is important to note that prior to 1985-88 the sole criteria for determining whether a soil was Cu deficient or not was the critical level of 0.2 mg/kg DTPA extractable Cu suggested by Lindsay and Norwell (1978). In other words, if a soil test indicated more than 0.2 mg/kg DTPA extractable Cu then the soil was deemed to have sufficient Cu for normal crop growth.

Seven years of research has clearly shown that there is a low probability of correctly diagnosing Cu deficiency if an agronomist only considers soil test DTPA extractable Cu. The probability of correct diagnosis increases dramatically if the same agronomist takes into account overall fertility management, soil type, soil copper profile and past observations of disease or Cu deficiency symptoms.

Fertility Management

Managers striving for optimal yields are generally the first to observe Cu deficiency in a farming area. Their fertility management often includes manure and above average rates of fertilizer. In many instances, their first indication of Cu deficiency are crop yields or bushel weights consistently below their expectations. Results presented in Table 1 are typical of many producers initial experience with Cu deficiency. In this case the farmer had been applying optimal rates of fertilizer and manure every 2-3 years. Yields, quality and weed control were disappointing and many different agronomists had given him several different reasons why his yields were lower than expected. With application of Cu, his crop quality and yield both improved dramatically. Producers who do not manage their fertility at a high level usually have yields that are limited by N, P, K or S before Cu can impact yields.

Table 1. Effect of copper fertilizer on yield and kernel plumpness of wheat and barley (1989)

Crop	Copper Rate (lb Cu/ac)	Yield (bu/ac)	% Kernel Plumpness
Klages Barley	0	62	48
	10	92	82
Park Wheat	0	15	59
	10	36	72

Copper applied at 10 lb Cu/ac as Copper Sulphate (Bluestone) in 1987

Soil Test Criteria

Soil test criteria for diagnosing Cu deficiency have been further modified for Alberta's growing conditions (Table 2). When soil tests are in the marginal ranges, crops should be carefully observed for symptoms of Cu deficiency (Table 5) and Cu fertilization tried on test strips. Fields with a history of heavy manure application and/or optimal NPKS fertilizer management (high yield potential) may respond strongly to Cu fertilizer even when the soil test is above 0.6 mg/kg.

Table 2. Soil copper levels for mineral soil diagnosis. DTPA extractable. 0-6" depth.

DTPA Cu (mg/kg)	Interpretation
< 0.4	Deficient
0.4 - 0.6	Marginal
0.6 - 1.0	Deficient in some instances
> 1.0	Usually adequate

Soil Type

Cu deficient soils have several characteristics that indicate where a deficiency will likely occur:

Table 3. Copper reduces take-all disease symptoms and melanosis in spring wheat cultivars (1993)

	Take-all %		Melanosis	
Cultivar	+ Cu	- Cu	+ Cu	- Cu
Roblin	4	70	none	slight to severe
Oslo	12	69	none	none
Laura	4	52	none	none
Park	6	78	none	slight to severe

0.6 mg/kg DTPA extractable Cu, Stony Plain Alberta.
Copper applied at 12 lb Cu/ac as Copper Sulphate

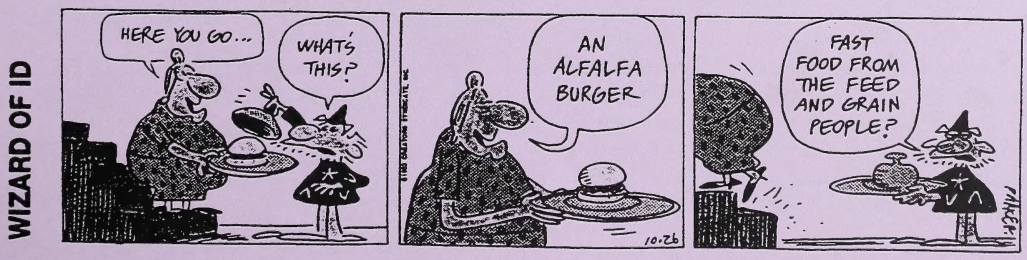
Table 4. Effect of copper fertilization on yield and ergot infection of Park wheat (1989).

Cu Rate (lb/ac)	Grain Yield (bu/ac)	Ergots (number/yard^2)
0	13	11
10	43	2

0.6 mg/kg DTPA extractable Cu, Stony Plain Alberta.
Copper applied at 10 lb Cu/ac (in 1987) as Copper Sulphate

Table 5. Copper deficiency symptoms in cereals (adapted from Graham and Nambiar, 1981).

	Degree of Deficiency		
Symptoms	**Slight**	**Moderate**	**Severe**
Limpness or wilting at mid-tillering			x
Limpness or wilting at stem elongation	x	x	
Pale yellow, curled young leaves at tillering			x
Pig tailing (Whip tailing) - leaf tip dies & may roll & turn white, sometimes appearing fibrous. Upper 1/3 to 1/2 of the leaf may whither & break abruptly at the healthy part.		x	x
Increased susceptibility to disease		x	x
The presence of ergots in grain heads, specifically wheat and barley.	x	x	x
Unusually high levels of take-all or "take-all" like symptoms in wheat.	x	x	x
Retarded stem elongation.		x	x
Excessive late tillering & high mortality of late tillers.		x	x
Delay in heading - Non uniform heading occurs, particularly on light loamy soils where crop emergence & early development is uniform.		x	x
Aborted heads and spikelets.			x
Heads & spikes are nearly normal, but contain many empty spikelets. Anthesis is poor & late. Grain is shrivelled & endosperm is blackened.		x	x
Delay in maturity & senescence - Maturity may be delayed for a few days to several weeks.	x	x	x
Head & stem bending - stem may break 15 to 30 cm. below the head.	x	x	
Stem & head melanosis of wheat - Dark brown patches that usually begin at the milky dough stage. Dark purplish brown colour (melanism) appears on head &/or upper stem &/or lower stem.	x	x	x
Probable loss in grain yield (%).	**5 - 20**	**20 - 50**	**50 - 100**
Probable loss in straw yield (%)	**nil**	**0 - 10**	**10 - 20**



Texture: Deep sandy and light loamy soils are more prone to Cu deficiency than medium or heavy textured soils. The parent material forming these soils often contain low Cu concentrations.

Organic Matter: Cu is strongly bound to organic matter. As organic matter increases the probability of Cu deficiency increases. Manure and straw from previous crops can also tie up Cu.

Soil pH: Copper availability is reduced as pH increases. A pH increase of 1 unit means a 100 fold reduction in Cu availability to the crop. Thus, for similar soils, as pH increases so does the probability of Cu deficiency.

Other Soil Nutrients: High soil test values for P_2O_5 and N are often associated with Cu deficient soils in Alberta. High N levels delay the translocation of Cu from older leaves to the growing points, thus enhancing Cu deficiency. High levels of P_2O_5, Zn, Fe, Mn and Al restrict Cu absorption by cereal roots.

Soil Copper Profile:

Soil copper profiles that remain low or decrease with depth have a much higher probability of responding to additions of Cu fertilizer than a soil which has soil Cu levels that increase with depth (Figure 1). In order to make a correct diagnosis it is critical to soil sample to at least 1 foot, preferably 2 feet.

Fig 1. Generalized soil Cu profiles typically found in Alberta.

	ppm Cu
0"	
6"	0.5
12"	0.4
24"	0.4

	ppm Cu
0"	
6"	0.4
12"	1.2
24"	2.8

Copper Deficiency Symptoms

Cu deficiency in cereals produces characteristic symptoms that may be similar for each species. However, crops growing on marginally Cu deficient soils may have losses of 20% or more in grain yield while not showing visual symptoms of a deficiency. Visual symptoms of Cu deficiency (Table 5) are commonly observed in fields of wheat, barley and occasionally oats. Many of these symptoms may be confused with other nutrient deficiencies (N, P, K, or S), frost damage, insect damage, diseases and herbicide damage. Herbicides are commonly blamed for yield losses because Cu deficiency symptoms usually show up about the same time that post-emergent herbicides are applied.

Deficiency symptoms usually occur in irregular patches and are most obvious in mature wheat stands that express Cu deficiency primarily as melanism or purplish brown patches (eg. cultivars Park and Roblin). Other varieties express Cu deficiency primarily as Take-all like symptoms (Table 3) which adds further confusion to Cu diagnoses (eg. cultivars Oslo and Laura).

High levels of ergot in wheat and barley can indicate potential Cu deficiencies (Tables 4 and 5).

For cereals the usual order of sensitivity (response) to Cu deficiency is winter wheat > spring wheat > barley > oats > triticale > rye. Canola has not expressed Cu deficiency symptoms or responded to Cu fertilizer additions when grown on soils very deficient for wheat or barley. Many other Alberta crops have yet to be evaluated for their sensitivity (response) to Cu nutrition.

CONCLUSION

Confident diagnoses of Cu deficiency requires much more than a simple scan of laboratory results from a 0-6" soil sample. Agronomists are being irresponsible if they do not ask:

(1) Is the soil coarse textured ?
(2) Is the topsoil rather deep (>12 ") ?
(3) Does the soil have a high level of organic matter (>6 %) ?
(4) Does the soil Cu profile remain low or decrease with depth (< 1.0 mg/kg) ?
(5) Does the soil test indicate relatively high levels of available P_2O_5 and/or N ?
(6) Does the farmer strive for above average yields ?
(7) Are his crop yields and/or quality consistently below expectation ?
(8) Is there a history of manure application ?
(9) When cropped to wheat or barley, have unusual patches appeared ?
(10) Have these patches been diagnosed by several "experts"? Many with different answers ?
(11) Do these patches contain unusually high levels of disease in some years ?
(12) Is ergot a problem in wheat or barley ?
(13) Have there been instances of unusually high herbicide injury ?

The greater the number of "YES" answers, the greater the confidence in correctly diagnosing a Cu deficiency. As diagnostic confidence increases, so does the production efficiency of the affected field and the farmers overall operation.

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CLEANING UP THAT WEED SPRAYER

Terry Footz

Why

Careful and complete cleaning of sprayer equipment is necessary to prevent crop injury caused by herbicide residues. Many herbicides are extremely active and are effective at very low rates. Even small amounts of some herbicides remaining in sprayer equipment will injure sensitive crops that are sprayed in subsequent applications.

When

Rinsing the sprayer with water at the end of a spraying day will prevent the chemical from drying and encrusting in the spray lines, strainers, nozzles and on the inside of the tank walls. Postponing sprayer clean out, even overnight will make the process more difficult.

When changing chemicals or before the sprayer is stored away, follow the complete sprayer cleaning procedure indicated on the herbicide label. Following is an example of a complete sprayer cleaning procedure.

Cautions

- Some pesticides have specific cleaning recommendations.
- Refer to the product label for cleaning instructions.
- Never clean a sprayer where rinse water can contaminate water supplies, damage desirable vegetation or be accessed by children, livestock or pets.
- Never use your mouth to blow a sprayer tip clean; use an air compressor.

How

1. Remove and clean nozzle tips and strainers.
2. Open boom ends and drain the tank.
3. Fill tank 1/3 full of clean water. Use a handgun attached to the pressure side of the pump to wash down the interior walls of the spray tank. Pump out the solution through the boom and drain the tank.
   a) The rinse solution from the first flushing will contain the highest herbicide concentration. This solution can be sprayed on a summerfallow field.
   b) If visible residues of chemical remain; repeat above process.
4. Add 1/3 tank of clean water and the recommended amount of the correct cleaning agent (see Table 1).
   - Wash interior of tank walls using the handgun.
   - Flush some solution through the booms and recirculate through the sprayer for 15 minutes
   - Pump out and drain.
5. To remove traces of the cleaning agent, rinse with clear water and flush through the booms.
6. Install cleaned nozzles and strainers.

Table 1. Sprayer Cleaning Agents

Neutra Sol	@ 450 g/100 L of water
Incide Out	@ .95 L/100 L of water
Tank & Equipment Cleaner	@ 450 g/100 L of water
Finish 7% ammonia	@ 0.5 L/100 L of water
Household ammonia	@ 1L/100 L of water

N.B. Before storing the sprayer for the winter, flush automotive antifreeze through the entire sprayer system. This will prevent freezing or corrosive injury resulting from any water left in the system.

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SOIL SAMPLING - THE NEED FOR A NEW APPROACH

Doug Penney
Doug Keyes, Norwest Labs

Matching fertilizer application rates to crop nutrient needs optimizes economic return and protects the environment. Properly calibrated soil tests done on samples that accurately represent a field provide a good basis for determining appropriate fertilizer rates. Most of the work done to improve soil testing has concentrated on analytical methods, calibration and interpretation but there has been little done to improve sampling methods. Sampling remains the "weak link" in soil testing.

Most fields are fertilized as one homogenous unit (one fertilizer rate fits all), even though soil characteristics and crop yields are often highly variable. In the near future, however the use of global positioning systems (GPS), computerized mapping and automated variable rate application technology will allow inputs to be matched to 'site specific' conditions. Soil sampling associated with 'precision' or site specific farming research is resulting in a re–examination of soil sampling methods. Current sampling methods are inadequate for precision farming systems and **may not be the best method for the current system of applying a uniform rate of fertilizer to one or more fields.** The key question is: Does one composite sample (including depth samples) made up of cores taken from throughout the field best represent the field?

There are several methods that have been described for field sampling. A common method is to take a minimum of 20 cores fairly evenly distributed over the entire field with the

rider that 'unusual' areas should be avoided. In order for this sampling method to provide reliable results, several conditions must be met:

- the nutrient levels and yield potential of the area sampled must not be too variable,
- it must be possible to identify and avoid unusual areas,
- the fertilizer recommendation determined for the majority of the field should not result in large yield losses in the unusual areas.

If the circumstances are such that one fertilizer recommendation is suitable for the majority of the field, this sampling method works well, provided that unusual areas can be avoided. **Unfortunately, some unusual areas cannot be identified visually and therefore are not avoided in routine sampling.** For example, some fields have areas with unusually high levels of P and K, possibly a result of high rates of manure application in the past. If soil cores taken from these areas are included in the composite sample, the resulting fertilizer recommendation will under–fertilize the majority of the field. Taking additional cores for the composite sample may not overcome the sampling problem. A good example of this was evident in the results from a CAESA funded Precision Farming Project being conducted on the PARI farm near Mundare, Alberta. The field (40 acres) was sampled using a 220 and 200 ft. grid (approx. one composite sample per acre). A composite sample of 15 cores was taken at each of the 40 sampling locations. The available K levels ranged from 115 to 620 lbs/acre. The average value was 270 lb/acre, which is above the critical value of 250. Therefore, a regular composite sample from the field would not likely result in a potassium recommendation. However, 20 of the 40 composite samples from the grid sampling were below the 250 lb/ac critical value. Potassium was not applied to the wheat crop grown in 1994. Lodging occurred on 20 to 30 per cent of the field, indicating that the includsion of K in the fertilizer program would have been beneficial.

While intensive grid sampling is effective for mapping the fertility status and other soil characteristics of fields, it is time consuming and cost prohibitive for regular soil testing purposes. Therefore new approaches to soil sampling need to be evaluated. One approach being evaluated by Norwest Labs is to identify representative sampling sites (i.e., one, two or three per field). If a small area (about one–quarter acre) can be identified that represents the typical condition (crop yields and soil nutrient status) of the majority of the field, it would be a more convenient and consistent sampling procedure. For example, if an 80 acre field and a small 'representative' area of the field were sampled five times (in each case, taking 20 soil cores per composite sample), the variation among the samples taken from the 80 acre field would be much greater than the variation among samples taken from the small 'representative' area.

If it can be established that a small area of a field (a benchmark site) can be sampled to consistently represent the conditions on the majority of the field, soil sampling could become more accurate and convenient. The results of studies being conducted by Norwest Labs look encouraging. Methods of choosing representative benchmark sampling sites need to be evaluated. (Watch for more discussion of sampling methods in the next issue of SOILutions).

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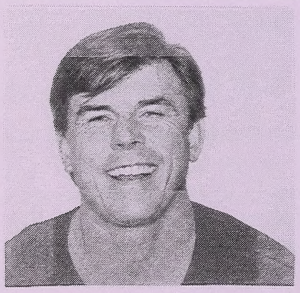

MEET THE SPECIALIST

Elston Denzil Solberg
Research Agronomist

Born and raised on a mixed dairy farm near Ryley some 80 km east of Edmonton on Highway 14. Graduated from University of Alberta with a B.Sc. in Agronomy in 1980 and a M.Sc. in Soils in 1986. Thesis title, "Oxidation of Elemental Sulphur Fertilizers in Agricultural Soils of Northern Alberta and Saskatchewan."

While working on Masters thesis I was employed full time (1980–87) with Dr. Marvin Nyborg (U. of A.) on a number of projects including:

- Efficient Management of Nitrogen Fertilizers.
- Effective Placement of Phosphate Fertilizers.
- Sulphur Deficiency of Cereals and Forages.
- Longterm Zero and Conventional Tillage Systems.
- Sulphur Deposition from Sour Gas Plants.

Since joining Alberta Agriculture I have worked primarily in research and extension on multi–agency cooperative projects including:

- MEY, Maximum Economic Yield. ICM, Intensive Crop Management.
- N Management to Improve Quality and Yield of Oats.
- Copper Deficiency Diagnosis and Correction.
- Field Evaluation of Lab Tests for Soil Phosphorus.
- Correction of N and S Deficiency of Canola with Postseeded Fertilizers.
- Effect of Simulated Topsoil Loss on Soil Productivity.
- Evaluation of New Elemental Sulphur Fertilizers.
- Optimal Seedplaced Fertilizer with AirSeeded Crops.
- Longterm Management Effects on Soil Quality.

I am married with 3 children, Dustin (12 going on 18); Kearstin (11) and Dylan (4). Our family moved back to Ryley 5 years ago and my wife (Maureen) and I both commute to Edmonton. I serve on Ryley Village Council and many volunteer boards such as the Beaver Heritage Agricuture Society. At my advanced sporting age I enjoy playing competitive sports of all kinds especially Twi–Light Baseball and Old Farts Hockey.

DEAR AGGIE

Dear AGGIE:

I grew Taber, a newly licensed prairie spring wheat, for the first time this year. The wheat was under irrigation and I followed all the usual growing recommendations. I was disappointed with the yield and the heavy infestation of ergot in the grain. What went wrong?

C.U. Deefishant

Dear C.U.:

In order to assess the ergot level in your grain I've consulted the book "Practical Crop Protection" developed by the Soil and Crop Management Branch. I'm sending you the information on ergot infestation levels, grain grades and ergot control in cereals.

Now to address the "root" cause of the problem. We know that ergot infection in small grain cereals, not including rye, is highly correlated with available soil copper. Additionally, application of some wheat herbicides, under conditions of low or marginally available soil copper will induce yield loss and facilitate ergot infestation.

To properly answer your question I need the full picture.
a) Soil analysis, including available copper,
b) Fertilizer application rates for the crop,
c) Herbicide used and growth stage (time) applied,
d) Presence of headland grasses around the crop – the source of ergot infestation.

When you provide the answers to the above questions, then I am sure I'll be able to spell out corrective measures.

Dear AGGIE:

I was disappointed in the control preharvest ROUNDUP (glyphosate) gave of the perennial sow–thistle I had in my field. Although I was very pleased with the control it gave on the Canada thistle, toadflax and quackgrass. Can you please tell me why I didn't get control.

I.M. Wondering

Dear I.M.:

Obviously it wasn't a sprayer or rate problem since you obtained satisfactory control of your other perennial weeds. There is a good possibility, however, that the sow–thistle you are dealing with is actually annual sow–thistle.

Surprisingly, we are seeing an increase in the annual sow–thistle populations in cultivated land. Perennial sow–thistle may be easily distinguished from annual sow–thistle by its creeping roots and large flower heads (up to 2 inches in diameter) If you pull the plants of annual sow–thistle the root would be a top root very much like a dandelion, because the plant goes to seed and seneses (dies) within the season.

Next year, plants will start from seed again so the preharvest ROUNDUP would not be effective in controlling this type of sow–thistle.

Your letters are welcome. Please mail or fax to:
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32nd Annual Alberta Soil Science Workshop

The Alberta Soil Science Workshop will be held March 13–15, 1995 in Grande Prairie. The plenary session theme is "Soil and Plant Health: Impact on land productivity and reclamation". Invited guest speakers will address various issues and developments in soil and plant health. In addition, the workshop will feature four technical sessions dealing specifically with soil fertility, inventory, conservation and reclamation. There will also be volunteer paper and poster sessions for individuals and groups to present new research results and ideas.

Anyone interested in submitting an paper and/or poster, or attending the workshop should contact Dr. George Clayton (403–354–2212) at the Agriculture & Agri–Food Canada Research Station, Beaverlodge, Alberta.

Personal Comments on "Environmentally Friendly Farming" article – Spring issue of SOILutions

Ross H. McKenzie

In the last issue of SOILutions Vol 5, No. 1, Spring 1994, Joan Rodvang, Denise Maurice, Elston Solberg, Murray Riddell, Graeme Greenlee and I wrote an article published under the title 'Environmentally Friendly Farming'. The submitted title was 'Minimizing Fertilizer and Herbicide Effects on the Environment'.

We put a fair amount of time and effort into the preparation of the article. The intent was simple! We wanted to heighten awareness of farmers and extension agronomists of practices that can be used today to avoid or even prevent environmental problems associated with the use of fertilizers and herbicides.

However, some concern was raised over the table in the article titled 'Contamination Potential of Some Commonly Used Pesticides'. The specific concern was the listing of leaching potential of over 40 herbicides.

The table in our article was based on a publication by Hirschi et al. (1993) titled 'Fifty ways to protect your groundwater'. The leaching potentials were based on relative differences in solubilities of the active ingredients in the herbicides and not on the absolute potential for contamination. The ratings used in their publication were: extra small, small, medium, and large.

In our article, we referred to the table to demonstrate to readers that herbicides have different leaching potentials. We also clearly stated that more detailed information was contained in the Alberta Agriculture publication 'Crop Protection with Chemicals, Agdex 606–1, 1994' (Blue Book), as well as from chemical manufacturers.

Further, we pointed out that there are a number of conditions that can influence potential herbicide movement, such as: soil textures (sandy versus clay), soil moisture conditions (drier versus wetter), fractured soils, irrigation management and environmental conditions after herbicide application.

The intent of the written information and the table was to encourage readers to be aware of herbicide leaching potential and introduce to readers some of the factors that can influence leaching potential. We suggested other sources for additional information.

The bottom line is that different herbicides have different leaching potentials. Also, leaching potentials are affected by a number of soil physical and chemical factors and environmental conditions. Farmers need to know the leaching potentials of the herbicides they are using. With this knowledge they can then make every effort to apply each herbicide under conditions that will minimize potential negative effects on the environment.

It is my personal opinion that we (industry and government agronomists) have a moral obligation to tell farmers how best to handle fertilizers and herbicides, to minimize environmental problems. If we don't take a pro–active approach now, the con–active, hard core environmentalists will have their way down the road.

Hirschl, M.C., Simmons, F.W., Peterson, D., and Giles, E. 1993. Fifty ways farmers can protect their groundwater. Northcentral Regional Extension Publication 522. University of Illinois Publisher.

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SOILutions was created in 1990 by Dan Heaney and Elston Solberg. Circulation has grown from about 200 to a distribution list of over 2,000. Our original audience was mainly Alberta Agriculture staff. It now includes government, industry, agronomists, producers, researchers, commodity groups and research associations. It reaches out as far as British Columbia, Saskatchewan and Manitoba.

During 1995 both Dan and Elston will be devoting their time and energy towards educational study. SOILutions will continue to be published with the editing assistance of Doug Penney, Ieuan Evans and Jill DeMulder until Dan and Elston can resume as editors.

Good luck with your studies Dan and Elston!

"To be smart is to believe only half of what you hear. To be brilliant is to know which half to believe".

SOILutions is published three times a year by the Soil and Crop Management Branch, Alberta Agriculture, Food and Rural Development. Your comments on current contents, ideas and contributions for future articles are welcome. For further information phone, fax or write to:

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